Environmental Resources' Property Ownership and Firms Behavior in Duopoly Market

Xu ZhiWei

Marketing Department, School of Business Tianjin University of Finance and Economics
Tianjin, China
xzhwtjufe@126.com

Abstract- **It's an effective method to avoid environmental resources market failure through defining property rights. The controversial issue is property ownership should be adopted between the free and the paid. Based on the Cournot model in duopoly market, the article discuss the relation between the ownership of property rights and firms behavior by calculating the environmental resources input and goods output under the condition of profit maximization. Through comparing with the market structure in three property ownership, non-delimitation, free-delimitation and paid-delimitation, we get the conclusion: we cannot reduce the consumption level of environmental resources only by the delimitation of property rights. And only with a certain price to allocate rights, it's possible to attain Pareto improvement in resources utilization. In addition, although the paid-delimitation ownership will lead to a decrease of total output, the firms still have a motivation to improve technical efficiency, because their own and total market output both have business with the utilization efficiency of environmental resources in this condition.**

Keywords- Environmental Resources; Property Ownership; Firms Behavior; Resources Input; Firms Output

I. INTRODUCTION

With the economic development, the environmental constraint to the firms' production is growing. Different with other production factors, most of the environmental resources have a non-competitive and non-exclusive character more or less. If there is no external action, it will be placed into public domain and formed "rent" pursued by all kinds of parties concerned. According to the Coase theorem, the solution is allocating public rights through an economical way, and regardless of the allocation result, it will eventually achieve efficient use of resources. In the course of the study, the article take environmental resources as a factor into production function, and describes the firms behavior's evolution in three property ownership: non-delimitation, free-delimitation and paid- delimitation, based on the Cournot model in duopoly market. And then, we calculate firms' environmental resources input and goods output in different ownership. By analyzing the results, we try to explore the optimal routine in favor of resources intensive use.

II. BASIC ASSUMPTIONS OF THE STUDY

Assumption 1: In the market, there are only two profit-maximizing firms i and j, who product the same goods, and have the same linear demand curve $p=\alpha-\beta(q_i+q_j)$.Both firms determine their own optimal output level founding on the opposing determination. In addition, regard to firm i, the cost is $c_i=\gamma+\delta q_i$ and the profit is $\pi_i=pq_i-c_i$; and regard to firm j, the cost is $c_j=\gamma+\delta q_j$, the profit is $\pi_j=pq_j-c_j$.

Assumption 2: Except environmental resources, there is no other input in the producing process. Environmental resources determine output by a linear mode $q=\varphi x$. The parameter x is the environmental resources input amount, and the parameter φ is the technical efficiency of resources. The parameter φ is greater, the output q is higher.

Assumption 3: To simplify the model, assuming that the property rights of environmental resources can be defined in cost-free forms, and no any cost will be caused in rights protection. That is, the market meets the basic condition for the Coase theorem - zero transaction costs.

III. THE FIRMS BEHAVIOR UNDER THE NON-DELIMITATION

Assuming the property rights in environmental resources is not defined completely. For any firms, once a specified amount of resources are consumed, the marginal cost is zero for the others. In other words, the firms' environmental resources inputs are all equal. Based on the hypothesis, the optimization problem is as follows:

$$\begin{cases} p=\alpha-\beta(q_i+q_j) \\ c_i=\gamma+\delta q_i \\ c_j=\gamma+\delta q_j \\ q_i=\varphi_i x \\ q_j=\varphi_j x \\ \pi_i=pq_i-c_i \\ \pi_j=pq_j-c_j \end{cases} \tag{1}$$

A. Discussion About the Environmental Resources Input

Solving profit-maximizing condition from (1), the optimal input amount of environmental resources is

$$x=\frac{\alpha-\delta}{2\beta(\varphi_i+\varphi_j)} \tag{2}$$

The result shows that both firms have the same environmental resources input, which is determined by the firms' technical efficiency φ_i and φ_j.The higher technical efficiency advance, the lower environmental resources deplete.

B. Discussion About the Firms Output

Solving profit-maximizing condition from (1), we also get the separate output of two firms and the total output of whole market:

$$q_i=\frac{\varphi_i(\alpha-\delta)}{2\beta(\varphi_i+\varphi_j)} \tag{3}$$

$$q_j = \frac{\varphi_j(\alpha-\delta)}{2\beta(\varphi_i+\varphi_j)} \quad (4)$$

$$Q = q_i + q_j = \frac{\alpha-\delta}{2\beta} \quad (5)$$

Through analysis, the output level q will depend on the environmental resources' use efficiency φ. Meanwhile, the ratio of output and efficiency is equal, namely $\frac{q_i}{q_j} = \frac{\varphi_i}{\varphi_j}$. However, total market output Q has nothing to do with φ. In addition, the product price is $p = \alpha - \beta(q_i + q_j) = \frac{\alpha+\delta}{2}$. The profit of firm i is $\pi_i = pq_i - c_i = \frac{\varphi_i(\alpha-\delta)^2}{4\beta(\varphi_i+\varphi_j)} - \gamma$, and j is $\pi_j = pq_j - c_j = \frac{\varphi_j(\alpha-\delta)^2}{4\beta(\varphi_i+\varphi_j)} - \gamma$ .Technical efficiency of environmental resources related to the profits. Therefore, even if not defined property rights completely, the firms still have the motives to improve technical efficiency.

IV. THE FIRMS BEHAVIOR UNDERTHE FREE-DELIMITATION

If the rights boundary in environmental resources is defined freely, for any firms, the marginal cost of resources is not zero. The firms choose a suitable resources input following the profit maximization principle: firm i input amount is x_i and firm j is x_j. Based on the hypothesis, the optimization problem is as follows:

$$\begin{cases} p = \alpha - \beta(q_i + q_j) \\ c_i = \gamma + \delta q_i \\ c_j = \gamma + \delta q_j \\ q_i = \varphi_i x_i \\ q_j = \varphi_j x_j \\ \pi_i = pq_i - c_i \\ \pi_j = pq_j - c_j \end{cases} \quad (6)$$

A. Discussion About the Environmental Resources Input

Solving profit-maximizing condition from (6), the optimal input amount of environmental resources is

$$x_i = \frac{\alpha-\delta}{3\beta\varphi_i} \quad (7)$$

$$x_j = \frac{\alpha-\delta}{3\beta\varphi_j} \quad (8)$$

Firstly, through the analysis of environmental resources optimal input in free-delimitation ownership, we can get the following conclusion: the input level is related with firm's technical efficiency, and the equation is $\frac{x_i}{x_j} = \frac{\varphi_j}{\varphi_i}$. Secondly, comparing the results with the market structure in non-delimitation ownership, we get the following conclusion: the use of environmental resources cannot be achieved Pareto improvement only by defining property rights. We can make the following proof as follows:

If firm i can reduce the input by free-delimitation way, there must be $x_i < x$, and so $x_i / x = \frac{\alpha-\delta}{3\beta\varphi_i} / \frac{\alpha-\delta}{2\beta(\varphi_i+\varphi_j)} = \frac{2\varphi_i + 2\varphi_j}{3\varphi_i} < 1 \Rightarrow \varphi_i > 2\varphi_j$. Similarly, there must be $x_j < x$ for firm j, and so $x_j / x = \frac{\alpha-\delta}{3\beta\varphi_j} / \frac{\alpha-\delta}{2\beta(\varphi_i+\varphi_j)} = \frac{2\varphi_i + 2\varphi_j}{3\varphi_j} < 1 \Rightarrow \varphi_i < \frac{1}{2}\varphi_j$ .Obviously, these two cases cannot exist simultaneously. Therefore, we prove that Pareto improving for the environment cannot achieve only by defining property rights' ownership.

B. Discussion About theFirms Output

Solving profit-maximizing condition from (6), we also get the separate output of two firms and the total output of whole market:

$$q_i = \frac{\alpha-\delta}{3\beta} \quad (9)$$

$$q_i = \frac{\alpha-\delta}{3\beta} \quad (10)$$

$$Q = q_i + q_j = \frac{2(\alpha-\delta)}{3\beta} \quad (11)$$

The results consistent with the Cournot model, and Q is greater than non-delimitation ownership. In addition, the product price is $p = \alpha - \beta(q_i + q_j) = \frac{\alpha+2\delta}{3}$.The profits of two firms are equal, which is $\pi_i = \pi_j = \frac{(\alpha-\delta)^2}{9\beta} - \gamma$. The important thing to note in the results is the firms output and profit are irrelevant with technical efficiency. Hence, even if the consumption of resources can be reduced through controlling parameter φ, any firms have no any motivation taken for this action.

V. THE FIRMS BEHAVIOR UNDERTHE PAID-DELIMITATION

If the firms need to purchase environmental resources with price ρ, then the payment would constitute a cost of firms. The optimization problem is as follows:

$$\begin{cases} p = \alpha - \beta(q_i + q_j) \\ c_i = \gamma + \delta q_i \\ c_j = \gamma + \delta q_j \\ q_i = \varphi_i x_i \\ q_j = \varphi_j x_j \\ \pi_i = pq_i - c_i - \rho x_i \\ \pi_j = pq_j - c_j - \rho x_j \end{cases} \quad (12)$$

A. Discussion About the Environmental Resources Input

Solving profit-maximizing condition from (12), the optimal input amount of environmental resources is

$$x_i = \frac{\alpha-\delta}{3\beta\varphi_i} + \frac{(\varphi_i - 2\varphi_j)\rho}{3\beta\varphi_i^2\varphi_j} \quad (13)$$

$$x_j = \frac{\alpha-\delta}{3\beta\varphi_j} + \frac{(\varphi_j - 2\varphi_i)\rho}{3\beta\varphi_i\varphi_j^2} \quad (14)$$

Firstly, comparing the results with the market structure in non-delimitation condition, if firm i can reduce the environmental resources input, there must be (13) less than (7), and so $\frac{(\varphi_i - 2\varphi_j)\rho}{3\beta\varphi_i^2\varphi_j} < 0 \Rightarrow \varphi_i < 2\varphi_j$. Similarly, for firm j, there must be $\frac{(\varphi_j - 2\varphi_i)\rho}{3\beta\varphi_i\varphi_j^2} < 0 \Rightarrow \varphi_i > \frac{1}{2}\varphi_j$ .It infer that there is a Pareto

improvement, and improvement condition is

$$\frac{1}{2}\varphi_j < \varphi_i < 2\varphi_j \tag{15}$$

Secondly, comparing with the non-delimitation condition, if firm i can reduce the environmental resources input, there must be (13) less than (2), and so $\left[\frac{\alpha-\delta}{3\beta\varphi_i}+\frac{(\varphi_i-2\varphi_j)\rho}{3\beta\varphi_i^2\varphi_j}\right]-\left[\frac{\alpha-\delta}{2\beta(\varphi_i+\varphi_j)}\right]<0$. The result of the equation is $\frac{(\alpha-\delta)\varphi_i\varphi_j(2\varphi_j-\varphi_i)+2\rho(\varphi_i+\varphi_j)(\varphi_i-2\varphi_j)}{6\beta\varphi_i^2\varphi_j(\varphi_i+\varphi_j)}<0$, and then we can solve the improvement condition:

$$\begin{cases}\varphi_i < 2\varphi_j \\ \rho > \dfrac{(\alpha-\delta)\varphi_i\varphi_j}{2(\varphi_i+\varphi_j)}\end{cases} \tag{16}$$

Similarly, for firm j, there must be:

$$\begin{cases}\varphi_i > \dfrac{1}{2}\varphi_j \\ \rho > \dfrac{(\alpha-\delta)\varphi_i\varphi_j}{2(\varphi_i+\varphi_j)}\end{cases} \tag{17}$$

Combined (16) with (17), we know, if and only if environmental resources technical efficiency is $\frac{1}{2}\varphi_j < \varphi_i < 2\varphi_j$, and the prices is $\rho > \frac{(\alpha-\delta)\varphi_i\varphi_j}{2(\varphi_i+\varphi_j)}$, the paid-delimitation condition is the lowest consumption level in three options.

B. Discussion About the Firms Output

Solving profit-maximizing condition from (12), we also get the separate output of two firms and the total output of whole market:

$$q_i = \frac{\alpha-\delta}{3\beta}+\frac{(\varphi_i-2\varphi_j)\rho}{3\beta\varphi_i\varphi_j} \tag{18}$$

$$q_j = \frac{\alpha-\delta}{3\beta}+\frac{(\varphi_j-2\varphi_i)\rho}{3\beta\varphi_i\varphi_j} \tag{19}$$

$$Q = q_i + q_j = \frac{2(\alpha-\delta)}{3\beta}-\frac{(\varphi_i+\varphi_j)\rho}{3\beta\varphi_i\varphi_j} \tag{20}$$

Firstly, compared (20) with (11), the output of whole market is clearly less than the non-delimitation condition. Secondly, (20) minus (5) equals $\left[\frac{2(\alpha-\delta)}{3\beta}-\frac{(\varphi_i+\varphi_j)\rho}{3\beta\varphi_i\varphi_j}\right]-\left(\frac{\alpha-\delta}{2\beta}\right)$ .As $\rho > \frac{(\alpha-\delta)\varphi_i\varphi_j}{2(\varphi_i+\varphi_j)}$, the total output of environmental resources under the paid-delimitation is also less than free-delimitation condition. Furthermore, the product price is $p=\alpha-\beta Q=\frac{\alpha+2\delta}{3}+\frac{(\varphi_i+\varphi_j)\rho}{3\varphi_i\varphi_j}$ [①]. It might also be noted that the separate output of two firms and the total output of the market are all relative with φ, when the environmental resources property ownership is divided by payment. In these cases, the firms have motivation to improve the environmental resources use efficiency.

① The profits' discussion in paid-delimitation state is omitted for too tedious calculations.

VI. A CASE ANALYSIS

The following is one case about how the firms will decide their behavior in different environmental resources' property ownership.

There are two farms planning to set up a cattle ranch in a village. Both of them know the following information distinctly:

- Once their cattle are sold in the near village fair, the market will form duopoly. And the market demand curve will be $p = 800 - 2(q_i + q_j)$.
- There is an adequate public meadow for grazing around the village. Therefore, any farm will not need to pay the additional fee for the forage.
- For any farm, the fixed cost of operation is 2500 dollars and marginal cost is 50 dollars in addition to the free forage.
- There is a different use efficiency of meadow between the farms. Farm i can graze four cattle per acre, and farm j is five.

Both farms know that they will have the same opportunity to use meadow, if the property rights of meadow are in non-delimitation condition. In other words, farm i realizes that farm j will obtain same meadow to grazing, once specific new meadow is reclaimed. And this is also so for the farm j . The reason lies in the fact that either side has no right to prohibit resources utilization by other producer. And the input of forage will be in this property ownership. According to (1), the optimal input of meadow will be 20.83 acres for both farms. The optimal amount of cattle will be 83.32 for farm i and 104.15 for farm j . Meanwhile, the equilibrium price will be 425.06 dollars. The profits of two farms will be 28750 dollars and 36562.5 dollars respectively.

If the property ownership is in the free-delimitation condition, any farm can no longer enter into the meadow belonging to the others at random. It means that the farms will choose their own meadow as the profit maximization principle, which will lead to the differentiation of initial input. Assuming the known condition remaining unchanged, two farms will occupy 31.25 acres and 25 acres meadow respectively. At the same time, the amount of cattle grazed by each farm will be 125. The equilibrium price will fall to 300 dollars for the higher supply level. And the maximized profits will be both 28750 dollars. Obviously, through defining property rights, the farms will reach the more elimination and the fewer profit than non-delimitation condition. Worse still, two farms can get a consistent profit by means of more resource consumption, although farm i has a lower technical efficiency. It means that the farms will be encouraged to plunder natural resources instead of technical innovation. The result is deviating from the original target to reduce resource-consuming, and Pareto improvement also have no way to achievement.

The result will be better, while the farms need to purchase property rights of the meadow for grazing with a given price rather than free distribution. If the farms have to pay 500 dollars per acre for the meadow rights to the local government, we can get the following conclusion for farm i: the meadow to be purchased will be 25 acres, the output to be grazed will be 100 cattle, and the profit he can reach will be 17500 dollars. In the same way, the meadow of farm j will be 22.5, the output will be 112.5, and the profit will be 22812.5 dollars.

Compared with the free-delimitation condition, whether farm i or farm j, the resources consumption are both less. Although the profits are reduced on the surface, the fact is not such. The local government will achieve 23750 dollars fiscal revenues with a transfer of the meadow rights in all. While all of those funds are returned to the farms, they can obtain 64062.5 dollars profit which will increase 6562.5 dollars than the free-delimitation condition. The only problem is the input of meadow is still higher than non-delimitation condition. The reason lies in that the selling price of resources is not high enough. If the local government pricing reach 900 dollars per acre, the issues will be resolved. The area of grazing will reduce to 20 acres and 20.5 acres, and the amount of cattle will also reduce to 80 and 102.5. Both are the lowest in the three conditions. Meanwhile, the profits of two farms will reach 10300 dollars and 18512.5 dollars. The total profits of them can grow to 65262.5 dollars, which is the highest in the three conditions. In addition, the paid-delimitation condition causes the resources utilization efficiency; quantity and profit are homonymous, which is the interest-oriented mechanism to achieve the strategy of sustainable development.

VII. CONCLUSION

The results show that, for firms, different property ownership directly affects the behavior performance. Even if there is nothing cost in the delimitation process, simply by the division of property rights cannot achieve the intensive use of environmental resources. If we set the goal as controlling the input of environmental resources, under certain conditions, paid-delimitation may be the optimal choice, but the firm's output is the lowest at this time. In addition, only in the condition of property rights defined with payment, the output of firms and market are both related with the use efficiency of resources, which will prompt the firms to adopt more intensive production methods. The selection will be propitious to coordinative development of economics and environment.

REFERENCES

[1] Bernheim, B. D. and Whinston, M.D. Multi-market Contact and Collusive Behavior. RAND Journal of Economics, pp1-26, January 1990

[2] Julien Hanoteau. The political economy of tradable emissions permits allocation. Political Economy of Environment Policy, pp1-20, March2003

[3] Li shoude, Huang tong cheng. The Initial Emission Rights Free-allocation and the Influence of Market structure. Systems Engineering Theory, pp 96-102, August 2005.

[4] Bohringer, C. and Lange. Economic Implications of Alternative Allocation Schemes for Emission Allowances. The Scandinavian Journal of Economics, pp563-581, March 2005

[5] Patrick Schmitz. Information Gathering, Transaction Costs and the Property Rights Approach, American Economic Review, pp 175-183, March 2006.

[6] Arjen Van Witteloostudn, Christophe Boone.A Resource-based Theory of Market Structure and Organizational Form. The Academy of Management Review, pp 409-426, March 2006

[7] Sterner,T. and Isaksson, L.H. Refunded Emission Payments Theory, Distribution of Costs, and Swedish Experience of NOx Abatement. Ecological Economics, pp93-106, April 2006

[8] Nicole Darnall1, Daniel Edwards. Predicting the Cost of Environmental Management System Adoption: the Role of Capabilities, Resources and Ownership Structure. Strategic Management Journal ,pp 301–320, April 2006

[9] Emilio Gomez, Does an Endogenous Relationship Exist between Environmental and Economic Performance? Environmental and Resource Economics, pp 73-89, January 2007

[10] Jason Davis, Kathleen Eisenhardt, Christopher Bingham. Optimal Structure, Market Dynamism and the Strategy of Simple Rules. Administrative Science, pp 413-452 September 2009.

[11] Daniel Millimet, Santanu Roy and Aditi Sengupta, Environmental Regulations and Economic Activity: Influence on Market Structure. Annual Review of Resource Economic, pp 98-108, April 2009.

[12] Zhang qishan, Yu weisheng. Economic Property Rights Structure and the Optimal Allocation of Production Factors. Economic Research Journal, pp35-42, June 2009

[13] Millimet,D.L.,Roy,S.,and Sengupta, Environmental Regulations and Economic Activity: Infuence on Market Structure. Annual Review of Resource Economics,pp99-117, June 2009

[14] K Fujiwara, Environmental policies in a differentiated oligopoly revisited, Resource and Energy Economics, pp 239-247, August 2009

[15] Juan Ma,Wen-Fa Xiao, Understanding Land Ownership and Environmental Conservation from Perspectives of enviro-capitalism and enviro-socialism, Journal of US-China Public Administration, pp15-23, June 2010